Polypropylene

Overview

Polypropylene is currently one of the fastest growing polymers, with forecasted demand growth higher than GDP for the foreseeable future. Much of this growth is attributed to polypropylene's ability to displace conventional materials (wood, glass, metal) and other thermoplastics at lower cost.

CB&I licenses its Novolen® gas phase polypropylene (PP) technology for the production of the full range of PP resins. This reliable, versatile and environmentally clean process makes products meeting the requirements of even the most demanding applications.

CB&I is the only company to offer technology integration between propylene and PP, with four processes aimed at producing or maximizing propylene from upstream refinery and petrochemical units.

Our tailor-made Novolen High Performance Catalyst Series (NHP) is complete with NHP® Catalyst Systems, which consists of internal and external donors. Novolen's catalyst series includes our standard Ziegler Natta 4th generation NHP 401 series and Ziegler Natta 5th generation NHP 402 series, which utilize non-phthalate components as internal donors. By applying NHP Catalyst Systems, our customers gain access to a broad, flexible operational window for their Novolen gas-phase PP plant covering standard, advanced and special polymer grades.

In addition to the NHP Catalyst Systems, the proprietary Novocene® technology including catalyst, polymerization technology, polymer products and related services such as engineering can be supplied.

NHP® Catalyst Systems and Novocene technology have proven to be drop-in solutions for the Novolen gas-phase process.

Advantages

Process Features	Process Benefits
Produces full range of PP products in two identical reactors with state-of- the-art catalysts	• Covers a variety of products for all markets/applications • Special products include bimodal grades for biaxially oriented PP (BOPP), low melt flow grades for pipes, and ultra-high (up to 50%) rubber-content impact copolymers
Exceptional lot-to-lot and within-lot uniformity	• Necessary for film and fiber applications, which need consistent and tight specifications
Mechanically agitated gas-phase process	• Among the lowest operating and maintenance costs in the industry • Fastest start-up times in the industry • Agitation independent from powder morphology, resulting in a unique product portfolio • No wall fouling and no shutdowns experienced due to lump formation
Low reactor volumes	• Reduced monomer inventory results in inherently safe process • Minimizes capital investment
Easy and highly reliable operation	• Rapid grade changes generate minimal "off-specification" product • Highest reported on-stream times in the industry
A solvent-free process with a unique vacuum degassing system in the extruder	• Very low taste and odor level for highly demanding applications
Two identical reactors without dedicated reactor for impact copolymers	• No unused parts or equipment maximizes ROI • Product mix can be adjusted to variable market needs • Both reactors always in use
"Drop in" Novocene metallocene technology available	• Portfolio of superior PP products especially for fiber, film and injection molding applications • Most advanced metallocene catalysts with highest activity currently available in the market

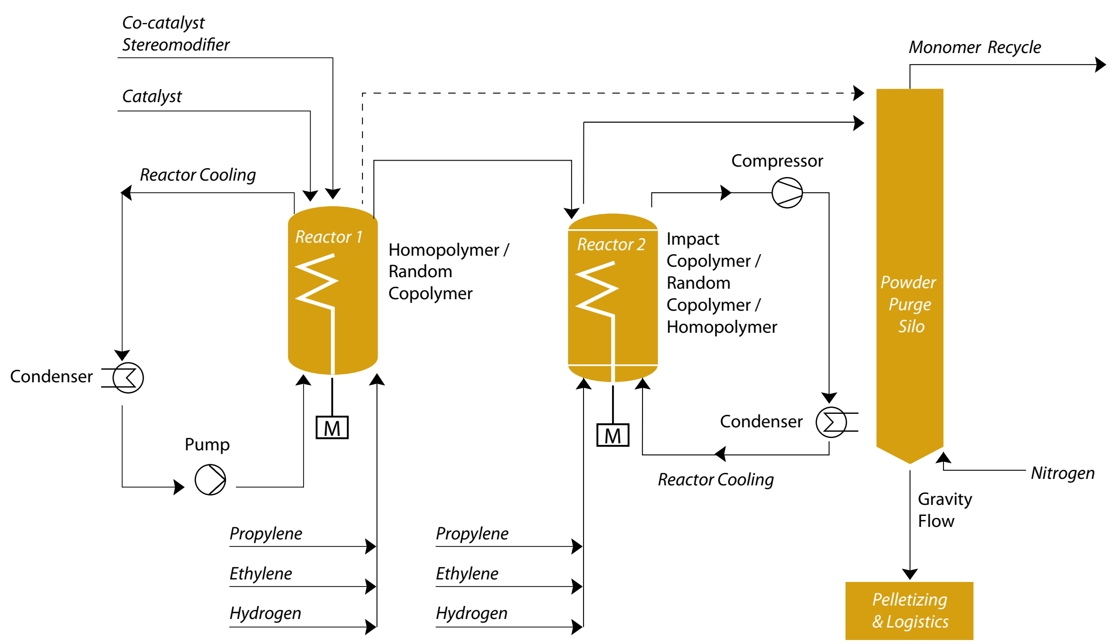
12M032015H_2-2 02.13.17

Performance Characteristics

CB&I's Novolen PP process utilizes one or two identical vertical, stirred bed, gas-phase reactors. Homopolymers and random copolymers can be manufactured either in a single, parallel reactor or in cascade operation of two reactors depending on the required capacity. Impact copolymers require two reactors connected in series: in the first reactor, propylene homopolymer or random copolymer is polymerized; in the second reactor, rubber is added by polymerizing an ethylene/propylene (rubber) mixture. The unique VRC® reactors is a Variable Reactor Concept (VRC) that allows switching between the two operational modes and by this unique process feature, it is possible to combine the broadest product capability with minimum investment.

Melt flow rate (MFR)	0.1 - 3000 g/10 min.
Isotacticity	90 - 99.5%+
Tensile modulus	400 - 2,400 MPa
Tensile yield stress	10 - 40 MPa
Impact strength	No break at -30°C
Transparency (1 mm disc)	Up to 96% for Ziegler/Natta PP Up to 97.5% for metallocene PP
Melting temperature	125 - 165°C
Sealing initiation temperature (SIT)	Down to 100°C

Process Flow Diagram



Process Description

Propylene, ethylene, and any other desired comonomers are fed into the reactor(s). Hydrogen is added to control the molecular weight. Polymerization conditions (temperature, pressure and reactant concentrations) are set by the polymer grade being made. The reaction itself is exothermic and reactor cooling is achieved by flash heat exchange, where liquefied reactor gas (mainly propylene) is mixed with fresh feed and injected into the reactor. Flash evaporation of the liquid in the polymer bed ensures maximum heat exchange.

The polymer powder is discharged from the reactor and separated from the unreacted monomer in a discharge vessel at atmospheric pressure. The monomer is compressed and recycled into the reactors. The remaining part is returned to the upstream (or ISBL) olefins unit for recovery in order to remove accumulated propane. The polymer is flushed with nitrogen in a purge silo to strip it of residual propylene. The purge silo offgas is passed to a membrane unit to recover the remaining monomers and the nitrogen for reuse. The powder is fed via gravity to the extruder, where it is then converted into pellets that incorporate a full range of well-dispersed additives.

It is important to note that both reactors are always in use, regardless whether homopolymer, random copolymers or impact copolymers are produced.

www.CBI.com